Missouri Department of Natural Resources
Water Protection Program

Total Maximum Daily Load (TMDL)

for

Lake Creek
Pettis, Morgan and Benton Counties, Missouri

Completed: April 28, 2008
Approved: July 15, 2008

Total Maximum Daily Load (TMDL)
Lake Creek
Pollutant: Sediment

Name: Lake Creek

Location: Pettis, Morgan and Benton counties

Hydrologic Unit Code (HUC): 10300103-030002

Water Body Identification (WBID): 875

Missouri Stream Class: Class P Stream[1]


State map showing location of watershed

Beneficial Uses[2]:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life.
- Protection of Human Health (Fish Consumption).
- Whole Body Contact Recreation (Category B).
- Cool Water Fishery.

Size of Impaired Segment: 5.0 miles[3]

Location of Impaired Segment: From SW ¼ Section 25, T45N, R20W (the mouth) to NE ¼ Section 12, T44N, R20W

Pollutant: Sediment

Pollutant Source: Agricultural Nonpoint Source

TMDL Priority Ranking: Medium

1. Introduction

This Lake Creek Total Maximum Daily Load (TMDL) for sediment is being established in accordance with Section 303(d) of the Clean Water Act. This water quality limited segment of Lake Creek in Pettis, Morgan and Benton counties is included on the EPA approved 1998 and 2002 303(d) lists for Missouri. Much of this TMDL was developed by EPA in 2006 to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*[4]. However, there was no actual data from Lake Creek to complete the Load Duration Curve

[1] Class P streams maintain permanent flow during drought conditions. See 10 CSR 20-7.031(1)(F).
[2] For Beneficial Uses see 10 CSR 20-7.031(1)(C) and Table H.
[3] 10 CSR 20-7.031 Table H currently lists the length of Lake Creek as 4.3 miles. Future revisions to Table H will reflect the correct 5.0 mile length of the segment.
[4] No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001.

(Figure 1). Therefore, the Missouri Department of Natural Resources (the department) collected the necessary data in the summer of 2007. The department completed this TMDL following the EPA format and using the graphs, flow and TMDL curve as calculated by EPA.

The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding the water quality standards (WQS) for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the Missouri WQS established for each water body based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA) and margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumption and data inadequacies.

2. Background and Water Quality Problems

Lake Creek is located in the Lamine River Basin in Pettis County. The impaired segment flows northeast and then northwest to join Flat Creek in southeast Pettis County. Flat Creek joins Richland Creek in Morgan County to form the Lamine River. Five miles of Lake Creek are listed as impaired for sediment due to agricultural nonpoint source runoff. The associated watershed is approximately 49 square miles. Grassland, deciduous forest and cropland are the predominate land uses in the watershed (Table 1 and Appendix A).

Table 1. Land Use Distribution for Lake Creek watershed.

Type	**Percent**
Barren or Sparsely Vegetated	<1
Cropland	19
Deciduous Forest	30
Deciduous Woody/Herbaceous	3
Grassland	45
Herbaceous-Dominated Wetland	<1
Impervious	<1
Low Intensity Urban	<1
Open Water	<1
Woody-Dominated Wetland	<1

All waters of the state, as per WQS, must provide a suitable condition for aquatic life. The conditions include both the physical habitat and the quality of the water. TMDLs are not written to address habitat, but are written to correct water quality conditions. The water quality condition addressed in this TMDL is sedimentation.

A combination of natural geology and land use in the prairie portions of the state (where Lake Creek is located) is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major problems are excessive rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and loss of stream channel heterogeneity due to channelization, and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. Loss of tree cover in riparian zones has caused

elevated water temperatures in summer and a reduction in woody debris, a critical aquatic habitat component in prairie streams. The most compelling evidence of loss or impairment of aquatic habitat is the historical changes in the distribution of fishes in Missouri. Many species of fish no longer appear in portions of the state where they once lived (MDNR, 2005).

Lake Creek was placed on the Missouri 303(d) List for sedimentation primarily based on best professional judgment because no sediment data exists to directly document sediment impacts to the stream. General fisheries data and the effect of sediment on fish were the initial data used to consider Lake Creek for 303(d) listing. Since the 303(d) listing, the department has developed a sediment protocol to determine if sediment is actually the pollutant in the streams listed and to arrive at a standard way to measure sediment. The first step of that protocol is a biological assessment to see if the biological community is actually impaired. However, a biological assessment is not yet available for Lake Creek. For this TMDL, sediment targets were derived using generalized information from the ecological drainage unit (EDU).

3. Description of Sources

3.1 Point Sources

There are two facilities in the Lake Creek watershed that have permits through the state permitting system[5], see Table 2. Both facilities are Confined Animal Feeding Operations (CAFO). CAFOs are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25-year, 24-hour rainfall/runoff event. Total potential animal units (AU) for each facility are approximately 996 AU. The actual number of animal units on site is variable, but typically less than potential numbers.

Table 2: Permitted Facilities

Facility - CAFOs	**Permit number**	**County**	**Design Flow**
Jantz, Gary	MO-G010046	Pettis	Non-discharging
Koehn, Victor & Audra	MO-G010246	Benton	Non-discharging

3.2 Nonpoint Sources

The primary cause of the sediment impairment to Lake Creek has been identified as pollution caused by agricultural nonpoint sources. Most of the watershed is grassland (45 percent), deciduous forest (30 percent), or cropland (19 percent). There are scattered sections of cropland located along the main stem of Lake Creek with the rest concentrated towards the southern end of the watershed. Cropland that is adjacent to and drains into Lake Creek, could

[5] The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

contribute to the sediment impairment. In addition to livestock in permitted CAFOs, there are other livestock in the watershed, including many horses, cattle and hogs held in pastures and feedlots (Table 3). Overland runoff during rain events can easily carry sediment from feed lots and cropland into the stream. Anywhere there is exposed land, soil will erode into the creek, increasing the turbidity and concentration of total suspended solids and decreasing the transparency. A certain amount of sediment enters streams naturally due to normal fluvial (flowing rivers and streams) processes. This is considered the background levels of total suspended solids. However, human impact on the land has greatly increased erosion, making sedimentation the number one pollutant in the country. Sediment becomes suspended during high flow events as soil along the banks is eroded and bottom sediment is resuspended. Sediment loading in Lake Creek comes predominantly from nonpoint sources.

Table 3. Livestock Estimates per County[6]

Livestock and Poultry	**Animal Units**	
Cattle	**Pettis County**	**Benton County**
Beef	29,529	22,515
Milk	785	1,289
Cow/Calf	61,874	44,897
Hogs/Pigs	36,731	1,501
Sheep/Lambs	1,167	595
Poultry		
Layers	251,966	(D)
Broilers	3,046,153	687,712
Turkeys	61,315	70,400
Horses/Ponies	1,335	1,195

(D) Withheld to avoid disclosing data for individual farms.

4. Description of the Applicable Water Quality Standards and Water Quality Targets

4.1 Beneficial Uses

Lake Creek WBID (875) has the following beneficial uses:

- Livestock and Wildlife Watering.
- Protection of Warm Water Aquatic Life.
- Protection of Human Health (Fish Consumption).
- Whole Body Contact Recreation - Category B.
- Cool Water Fishery.

The stream classifications and designated uses may be found at 10 CSR20-7.031(1)(C) and (F) and Table H.

[6] USDA- NASS Quick Stats (Livestock) 2002 Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf

Use that is impaired:

- Protection of Warm Water Aquatic Life.

4.2 Antidegradation Policy

Missouri's Water Quality Standards (WQS) include the U.S. Environmental Protection Agency (EPA) "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after Nov. 28, 1975, the date of EPA's first WQS Regulation, or uses for which existing water quality is suitable unless prevented by physical factors such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support the propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. Before water quality in Tier 2 waters can be lowered, there must be an anti-degradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no degradation of the quality of these waters (with the exception of some limited activities that result in temporary and short-term changes in water quality).

4.3 General Criteria

The impairment of this water body is based on exceedence of the general, or narrative, criteria contained in Missouri's WQS, 10 CSR 20-7.031(3)(A), (C) and (G).

(A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses.

(C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses.

(G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

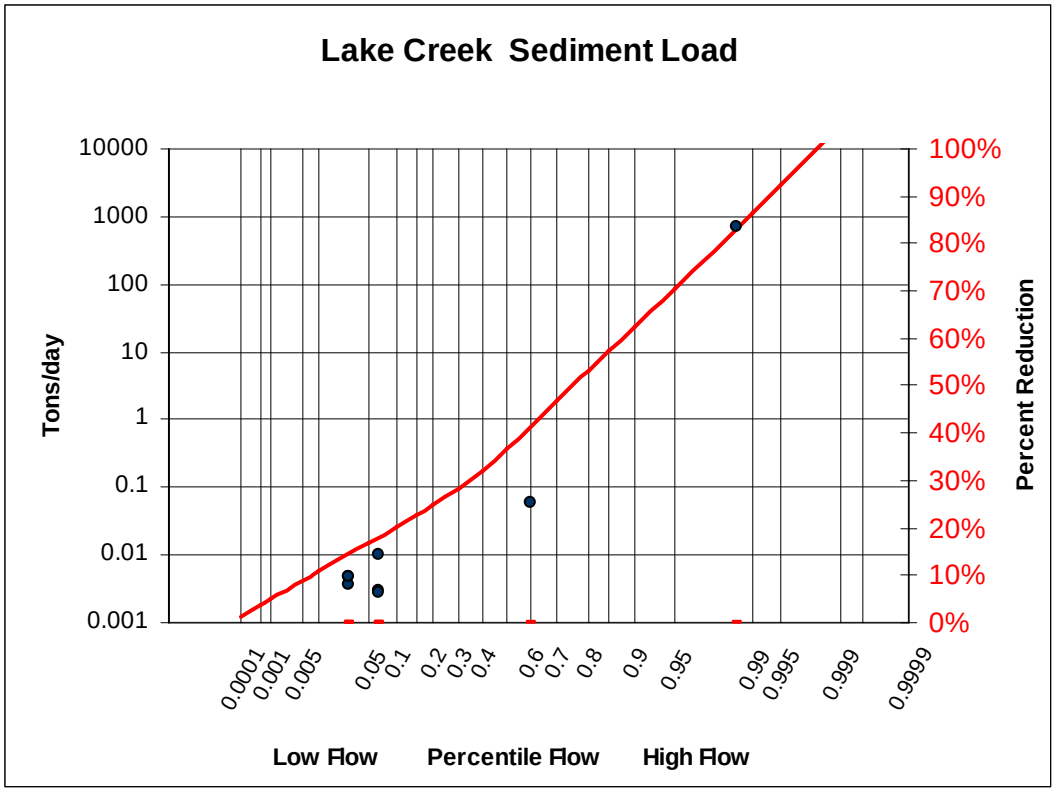
When the WQS is expressed as a narrative value, a measurable indicator of the pollutant may be selected to express the narrative as a numeric value. There are many quantitative indicators of sediment, such as Total Suspended Solids (TSS), turbidity, and bedload sediment,

which are appropriate to describe sediment in rivers and streams.[7] TSS was selected as the numeric target for this TMDL because it enables the use of the highest quality data available and is included in permit requirements and monitoring data.

5. Calculation of Load Capacity

Load capacity (LC) is defined as the maximum pollutant load that a water body can assimilate and still attain WQS. This total load is then divided among a Wasteload Allocation (WLA) for point sources, a Load Allocation (LA) for nonpoint sources and a Margin of Safety (MOS). The LC for this TMDL has been defined as a curve over the range of flows for Lake Creek, see Figure 1, where the red curve is the TMDL. Measurements are shown in Figure 1, where the round (black) points are loads calculated from TSS concentrations in Lake Creek and the corresponding horizontal (red) bars are the percent reduction needed to meet the TMDL.

Figure 1. TMDL Curve for Lake Creek.



[7] Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

5.1 Modeling Approaches

In the case of Lake Creek, where narrative standards are targeted for the impaired segment, a reference approach is used. For a full description of the development of suspended sediment targets using reference load duration curves (LDC) refer to Appendix C. In this approach, the target for pollutant loading is the 25th percentile of the current ecological drainage unit (EDU) condition calculated from all data available within the EDU in which the water body is located. Therefore, the 25th percentile is targeted as the TMDL LDC. Table 4 translates percentile of flow to segment flow for Lake Creek in cubic feet per second.

Table 4. Estimated flow for range of percentiles at the impaired segment outlet.

	Percentile of Flow	Discharge (cubic feet per second)
Flow Estimate for Lake Creek Based on Drainage Area and Synthetic Ecological Drainage Unit Flow	0.1	0.62
	0.3	2.16
	0.5	5.45
	0.7	14.6
	0.9	67.7

6. Waste Load Allocation (Point Source Loads)

WLA is the allowable amount of the pollutant that can be assigned to point sources. Both permitted facilities in the watershed are CAFOs and have non-discharging permits. Therefore, the WLAs are set at zero for both facilities. There are no other point sources or storm water sources located in the Lake Creek Watershed.

7. Load Allocation (Nonpoint Source Loads)

LA is the allowable amount of the pollutant that can be assigned to nonpoint sources. The modeling of Lake Creek shows no exceedance of the TMDL curve (refer to Figure 1). The TMDL curve is set as an estimate of expected reference conditions over a range of flows. The LA for Lake Creek is the TMDL minus the WLA, over the range of flows.

8. Margin of Safety

A Margin of Safety (MOS) is usually added to a TMDL to account for the uncertainties inherent in the calculations and data gathering. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

A. Explicit – Reserve a numeric portion of the LC as a separate term in the TMDL.
B. Implicit – Incorporate the MOS as part of the critical conditions for the WLA and the LA calculations by making conservative assumptions in the analysis.

All available data for Lake Creek indicates that the TMDL is being met (Table 1). This is conservative evidence that the TMDL will be protective of the designated uses and therefore an implicit MOS is assigned to this TMDL.

9. Seasonal Variation

The TMDL curve represents flow under all seasonal conditions. The LA and TMDL are applicable at all flow conditions, hence all seasons. The advantage of a load duration curve approach is to avoid the constraints associated with using a single-flow critical condition during the development of a TMDL. Therefore, all flow conditions including seasonal variation are taken into account for TMDL calculations.

10. Monitoring

Although the available data show no exceedances of the TMDL curve, a bioassessment study of Lake Creek is scheduled for 2008. This will demonstrate whether the biological community is impaired or not. In addition, the department will routinely examine physical habitat, water quality, invertebrate community and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring (RAM) Program. This program randomly samples streams across Missouri on a five to six year rotating schedule.

11. Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). As stated earlier, this water quality limited segment of Lake Creek in Pettis, Morgan and Benton counties is included on the EPA approved 1998 and 2002 303(d) lists for Missouri. EPA and the department's Water Protection Program developed this TMDL. The public notice period was from March 26 to April 25, 2008. Groups that received the public notice announcement included the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, the affected facilities, 18 Stream Team Volunteers in the area and the three state legislators representing Pettis, Morgan and Benton counties. Also, the department posted the notice, the Sediment TMDL Information Sheet and this document on the department Web site, making them available to anyone with access to the Web. No comments were received.

12. Administrative Record and Supporting Documentation

An administrative record on the Lake Creek TMDL has been assembled and is being kept on file with the Missouri Department of Natural Resources. It includes any studies and the data and calculations this TMDL is based on.

13. Appendices

Appendix A – Map of Lake Creek Watershed
Appendix B – Map of Lake Creek showing impaired segment and sampling sites
Appendix C – Development of Suspended Sediment Targets using Reference Load Duration Curves
Appendix D – Ecological Drainage Unit (EDU) Sites Used In Flow and TMDL Development.
Appendix E – Data collected from Lake Creek used to populate the TMDL curve

14. References

Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

NASS Quick Stats (Livestock) Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data, USDA, 2002. http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf.

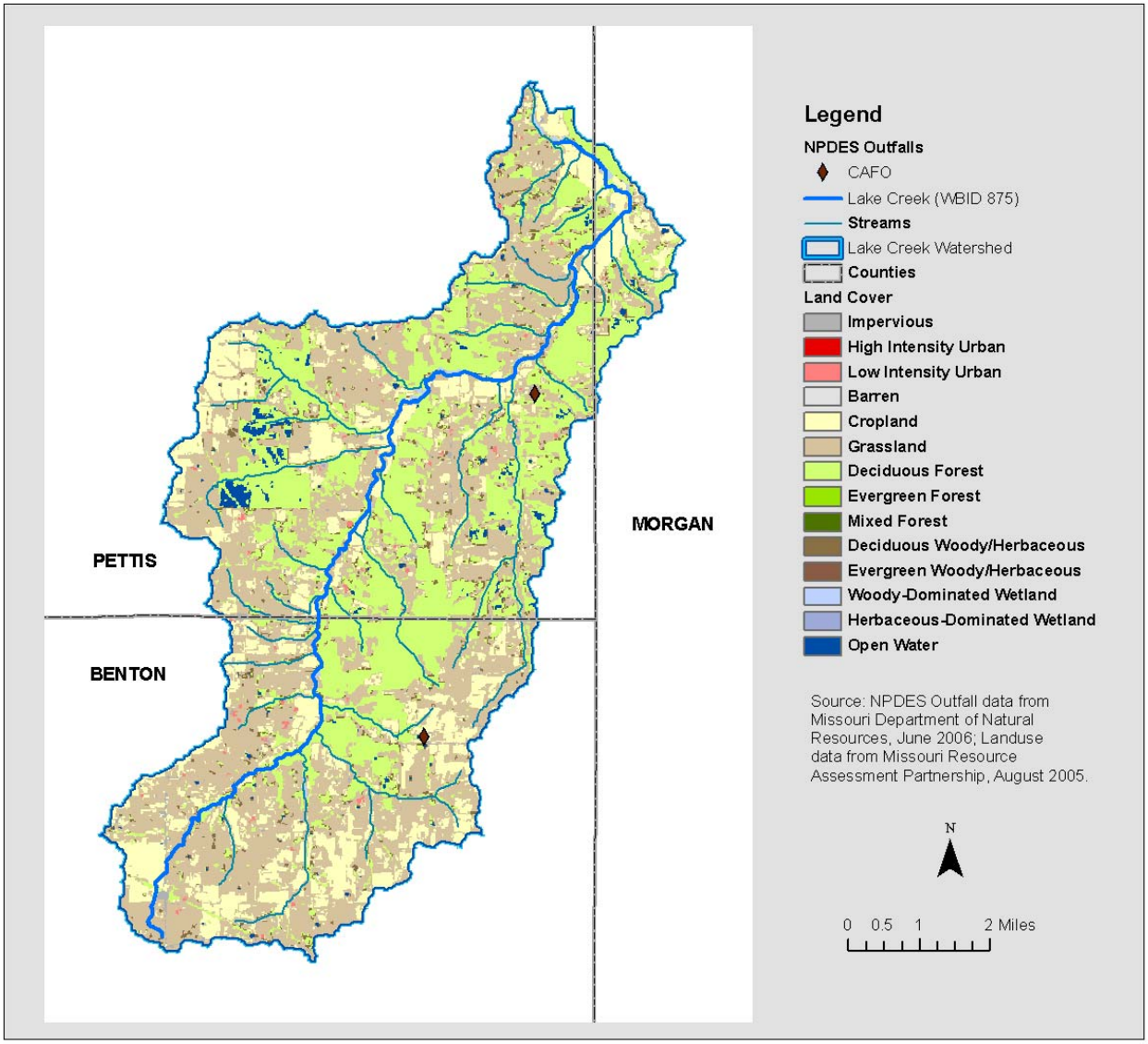
Quality Assurance Project Plan for Wasteload Allocations/Special Studies, Missouri Department of Natural Resources, 2007.

Missouri Department of Natural Resources, 2005. Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf.

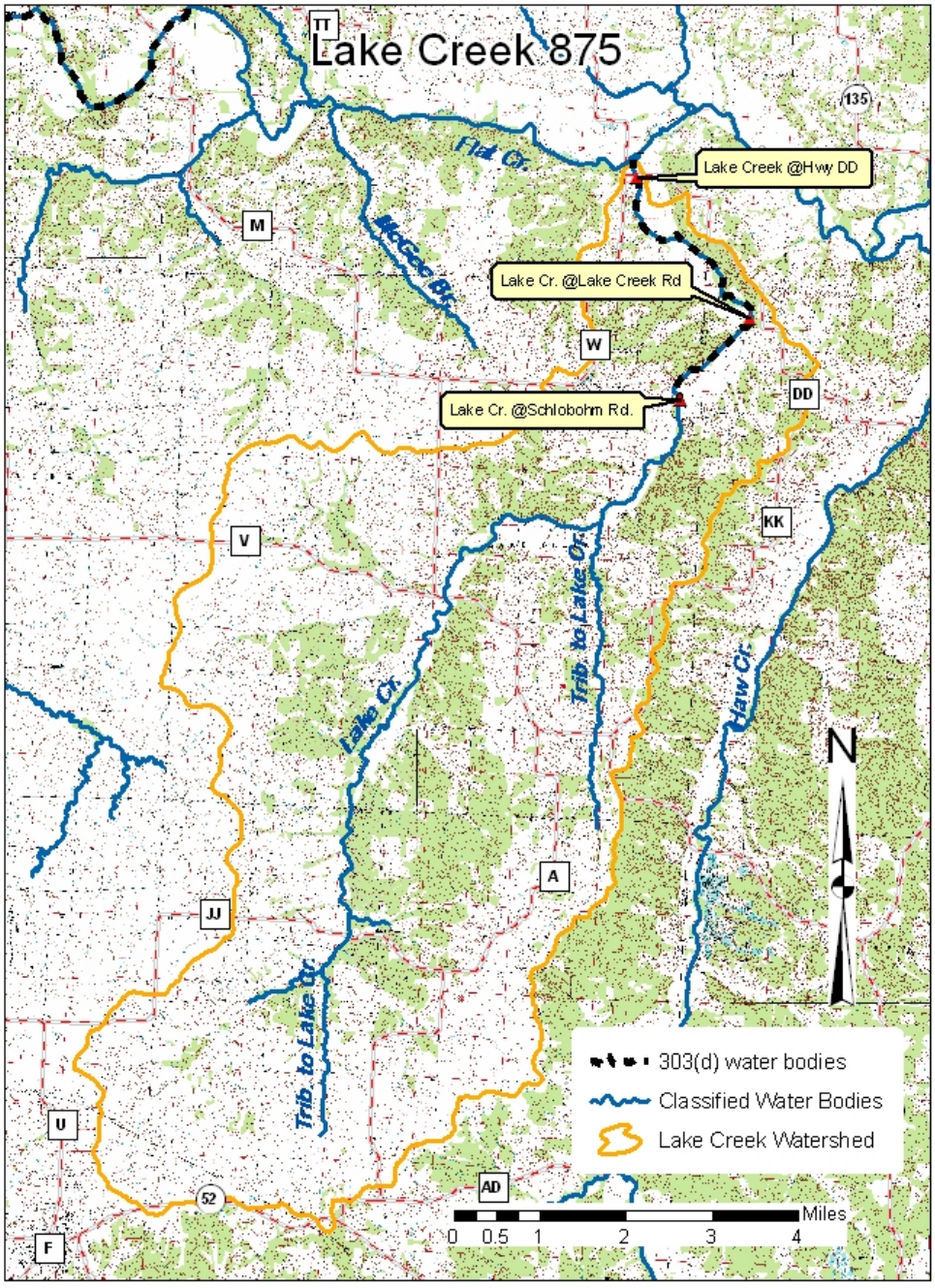
USEPA (2006). Development of Suspended Sediment Targets using Reference Load Duration Curves, EPA Region 7, Kansas City, KS

Appendix A

Map of Lake Creek Watershed



Appendix B
Map of Lake Creek showing the impaired segment and sampling sites



Appendix C

Development of Suspended Sediment Targets using Reference Load Duration Curves

Overview

This procedure is used when a lotic[8] system is placed on the 303(d) List for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the ecological drainage unit (EDU) in which the water body is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case, a synthetic flow record is needed. In order to develop a synthetic flow record calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. From this synthetic record develop a flow duration from which to build a load duration curve for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets in lakes and reservoirs. In this methodology the average concentration of either the 75th percentile of reference lakes or the 25th percentile of all lakes in the region is targeted in the TMDL. For most cases available pollutant data for reference streams is also not likely to be available. Therefore follow the alternative method and target the 25th percentile of load duration of the available data within the EDU as the TMDL load duration curve. During periods of low flow the actual pollutant concentration may be more important than load. To account for this during periods of low flow the load duration curve uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1 percent of the stream flow. This result in an inflection point in the curve below which the TMDL is calculated using load calculated with this reference concentration.

Methodology

The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

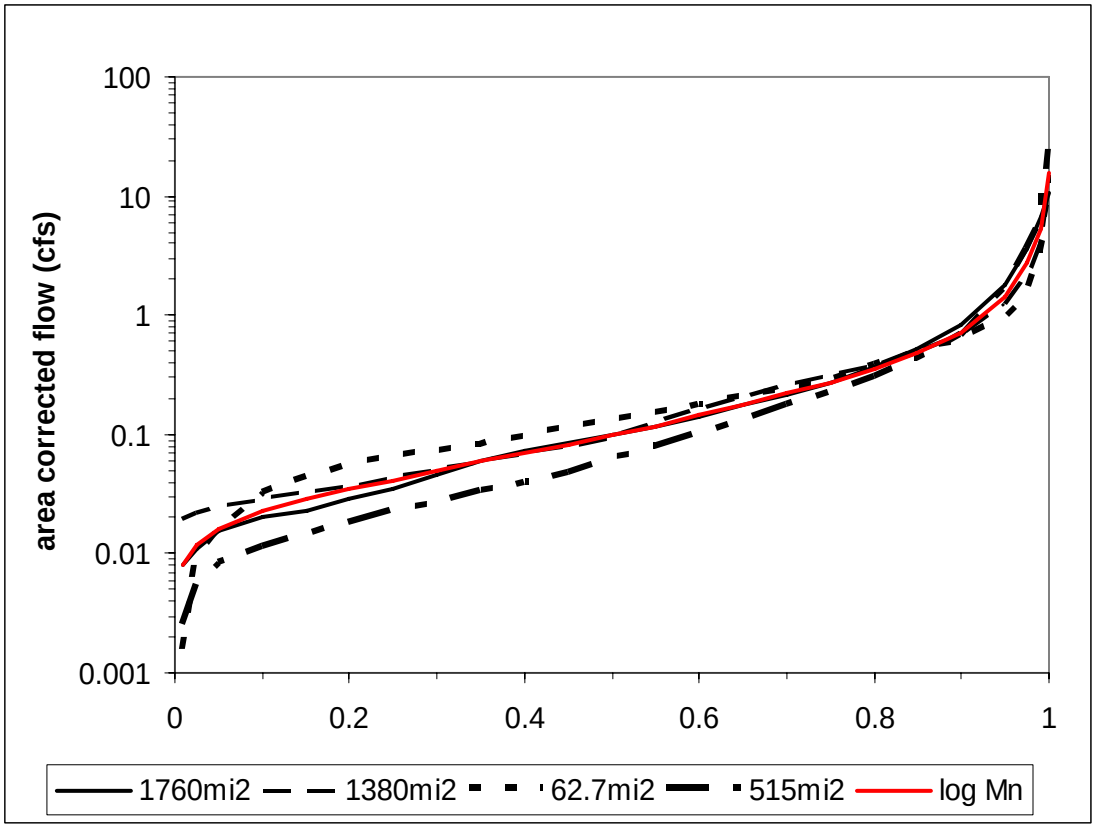
Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the

[8] Lotic = pertaining to moving water

average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow.

The following examples show the application of the approach to one Missouri EDU.

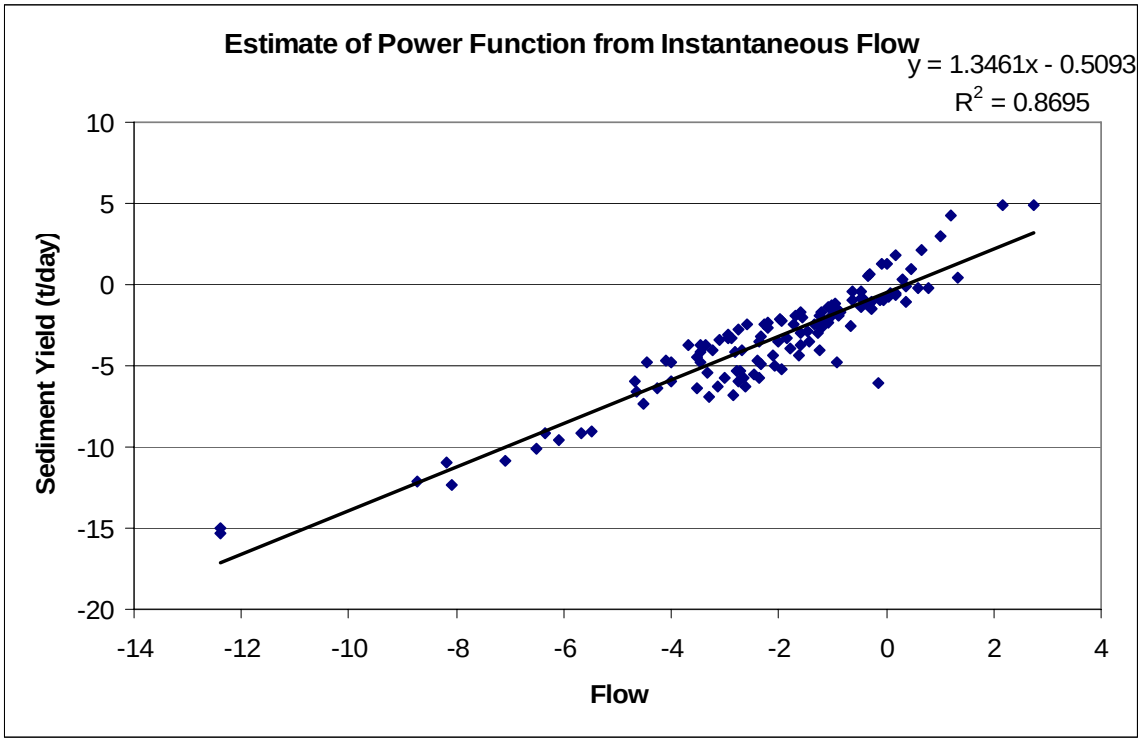
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The results of this analysis are displayed in the following figure and table:



Gage	gage	area (mi^2)	normal Nash-Sutcliffe	lognormal Nash-Sutcliffe
Platte River	06820500	1760	80%	99%
Nodaway River	06817700	1380	90%	96%
Squaw Creek	06815575	62.7	86%	95%
102 River	06819500	515	99%	96%

This demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi^2/day) and the instantaneous flow (cfs/mi^2.) The following graph shows the EDU relationship:



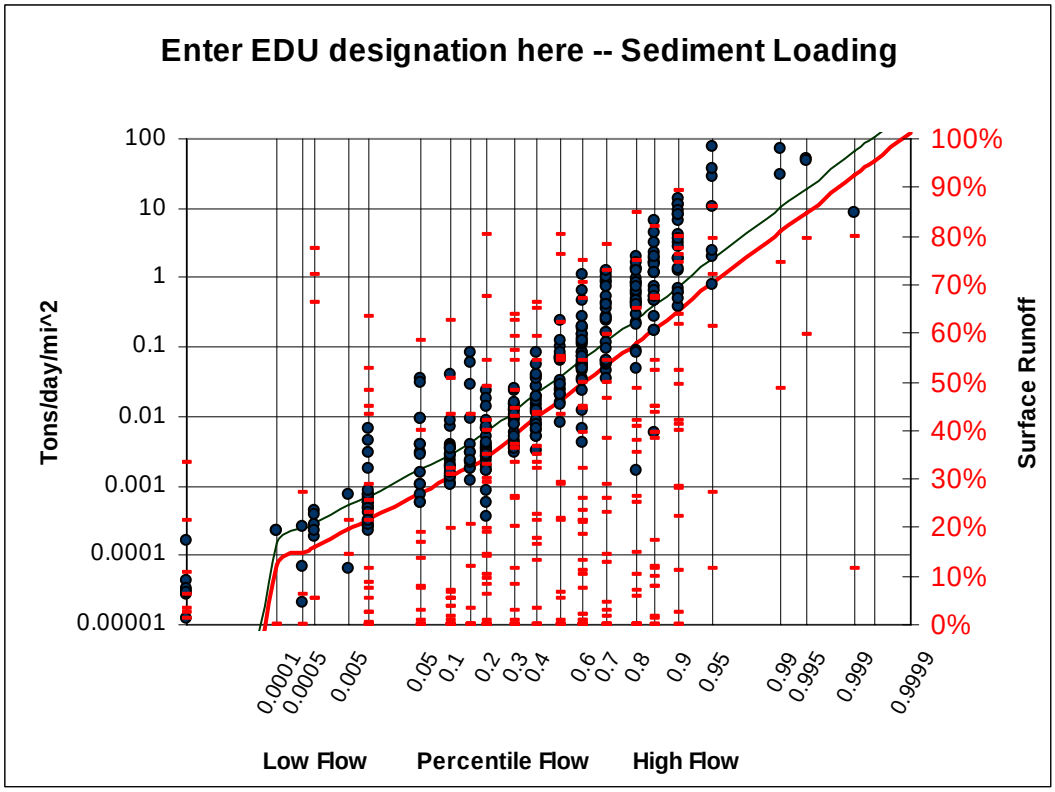
Further statistical analyses on this relationship are included in the following Table:

m	1.34608498	b	-0.509320019
Standard Error (m)	0.04721684	Standard Error (b)	0.152201589
r^2	0.86948229	Standard Error (y)	1.269553159
F	812.739077	DF	122
SSreg	1309.94458	SSres	196.6353573

The standard error of y was used to estimate the 25 percentile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z_{75} statistic times the standard error of (y). The resulting TMDL Equation is the following:

*Sediment yield (t/day/mi^2) = exp (1.34608498 * ln (flow) - 1.36627)*

A resulting pooled TMDL of all data in the watershed is shown in the following graph:



To apply this process to a specific watershed would entail using the individual watershed data compared to the above TMDL curve that has been multiplied by the watershed area. Data from the impaired segment is then plotted as a load (tons/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis.

For more information contact:
Environmental Protection Agency, Region 7
Water, Wetlands, and Pesticides Division
Total Maximum Daily Load Program
901 North 5th Street
Kansas City, Kansas 66101
Website: http://www.epa.gov/region07/water/tmdl.htm

Appendix D

Ecological Drainage Unit (EDU) sites used in flow and TMDL development

USGS stream gages used to generate synthetic flow

Lamine River nr Otterville	06906800
Blackwater R at Blue Lick	06908000

USGS stream sample sites used to generate EDU TMDL

Blue River nr Stanley KS	06893080
Blue River at Kenneth Road, OP KS	06893100
Lamine River near Pilot Grove, MO	06907300
Lamine River near Blackwater, MO	06908800

Appendix E

Data collected from Lake Creek used to populate the TMDL curve

Site Name	Year	Mo	Day	Time	Flow	C	DO	pH	SC	TSS	TSS Method	TRB
Lake Cr. @Lake Creek Rd.	2007	9	21	1244		22		8	441	6	SM 2540-D	2.8
Lake Cr. @Lake Creek Rd.	2007	8	29	1120		26	5.1	8	450	2.5	SM2540-D	1.3
Lake Cr. @Schlobohm Rd.	2007	8	29	1200		26	5	8	488	9	SM2540-D	5.6
Lake Cr. @Schlobohm Rd.	2007	9	21	1341	0	22		8	427	7	SM 2540-D	3.3
Lake Creek @Hwy DD	2007	8	29	1035		26	5.9	8	421	2.5	SM2540-D	1
Lake Creek @Hwy DD	2007	5	18	1315	4.57	20	10	8	339	2.5	SM 2540_D	2.1
Lake Creek @Hwy DD	2007	6	29	1300	497	22	6.8	8	106	563	SM 2540-D	280
Lake Creek @Hwy DD	2007	9	21	1102		21		8	470	7	SM 2540-D	3

Note: Flow in cubic feet per second; C=temperature in degrees Celsius; DO=Dissolved Oxygen in mg/L; SC=Specific Conductivity in microsiemens per centimeter; TRB=turbidity in NTU